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# Signposts on the digital highway The effect of semantic and pragmatic hyperlink previews

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## Abstract

In this article, the effect of a local, content (as opposed to structure) oriented navigation tool is investigated, i.e. mouse-over hyperlink previews. A usability experiment is described in which three groups of participants were exposed to three different versions of a website: without hyperlink previews, with content oriented, semantic previews, and with task-oriented, pragmatic previews. Participants were asked to execute search and recall tasks, and to evaluate task and hypertext. The results showed a decisive overall advantage for previews in terms of efficiency, but no effects on effectiveness or appreciation. Although semantic and pragmatic previews did not differ significantly, a post hoc analysis showed a learning effect of pragmatic previews that was absent in the semantic preview condition. It was concluded that previews fit in with the step-by-step goal orientation of hypertext users. Once users are acquainted with them, pragmatic previews speed up decision making.

Apart from the experimental part, the article surveys research into the usability of navigation tools, thereby focusing on the analysis of navigation tools. The bottom line of this review is that most navigation tools as they are used in the experiments provide users with different types of information, e.g. local vs. global, content vs. structure oriented. This complicates the unequivocal explanation of their effect and may explain, together with user and task differences, the variety and inconsistencies observed in the results.

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**Keywords:** Hypertext; Navigation; Previews; Advance organisers

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## 1. Introduction

A major concern in the design of hypertext is to provide users with an environment that enables them to execute tasks effectively and efficiently. In terms of hypertext design, users may be supported by two types of design characteristics, i.e. intrinsic and additional design variables.

Intrinsic design variables refer to the inherent structure, content and medium type of hypertext information. Hypertexts range from purely linear over hierarchical and mixed to completely ‘networked’ structures, and they consequently differ substantially in the way in which they allow and regulate the user’s access to information. Different access options affect the usability of hypertext, in interaction with types of users and tasks (e.g. Potelle and Rouet, 2003; Rada and Murphy, 1992; Van Nimwegen et al., 1998). Hypertext structures differ in the degree in which they reflect familiar content structures; familiar spatial structures, for instance, seem to benefit users, as is shown for example by Kim (1999) who demonstrated the advantages of the spatial metaphor of a shopping mall in accessing and using hypertext. The size of the information space and the number of chunks or pages range from small to almost infinite. The medium type of the information varies from (written) text to a multimodal melting pot of written and auditory text, music, visuals, animation, and virtual reality.

These intrinsic design characteristics are not ‘naturally’ given; they are the result of conscious efforts on the part of the information space designer. Still, they are different from additional variables that are specifically intended to guide users through their information processing task, i.e. navigational presentation tools and techniques such as hierarchical navigation bars (bread crumbs), paging buttons, alphabetical content lists, history tools, menus (expandable), back buttons, maps (conceptual/spatial/hierarchical/spider/site/concept), hyperlink previews, guided tours, bookmarking techniques, etc. These tools are part of the user interface and they are presented on top of the intrinsic structure of the information. Despite their diversity in terms of visualisation, animation, and interaction, they all basically are aimed at helping the user in creating a representation of the global or the local structure or content of the information, or at clarifying the user’s position within the information space or within his or her own path through the information space.

The main goal of this article is to investigate the effect of one such navigation tool, i.e. local hyperlink previews. Apart from that, we intend to demonstrate the relevance of a functional analysis of navigation tools, in general, and of hyperlink previews, in particular, as an indicator or predictor of their effect on hypertext users.

In Section 2, an analysis is given on the types of information and usability options provided by the navigation tools as they are used in experimental usability research. The survey prepares the implementation of hyperlink previews in the experiment to come, but it also shows the combinatorial character of navigation tools, which complicates the prediction and explanation of their effect and which may explain, together with user and task differences, the variety and inconsistencies observed in the results in this area of research.

Section 3 describes a usability experiment we conducted in which participants were exposed to one of three website versions: without hyperlink previews, with content

oriented hyperlink previews, or with task-oriented hyperlink previews. The participants were asked to execute search and structure recognition tasks, and to evaluate the hypertext and their task. The study concludes with a discussion of the results of the experiment.

## 2. Navigation tools and information types

### 2.1. *Supporting structure, content, and task: the case of navigation maps*

In general, navigation tools can be said to support the user in solving the well known triple navigation problem they are confronted with: Where am I?, Where do I have to go next?, and How do I get there? (Elm and Woods, 1985). Likewise, they can be claimed to decrease two equally well-known cognitive problems associated with the use of hypertext: disorientation and cognitive overhead (Conklin, 1987). Despite the large body of research into the effects of navigation tools, the overall results are far from conclusive. It remains as yet unclear how navigation tool characteristics relate to cognitive tasks associated with hypertext use. Even for tools with an intuitively plausible and clear-cut beneficial effect, research does not provide a coherent picture. Map-like navigation tools are a case in point here. On the one hand, a large number of studies have produced an equally large number of beneficial effects of map-like navigational tools. For instance, Chen and Rada (1996) conclude in their meta-analysis of usability studies that graphical maps have a significant impact on the usefulness of hypertext. Likewise, a large number of studies claimed clear beneficial effects of maps in terms of navigation efficiency, (durable) recall, or appreciation (Chien Chou and Sun, 2000; Danielson, 2002; Dee-Lucas and Larkin, 1995; Gupta and Gramopadhye, 1995; Kim, 1999; McDonald and Stevenson, 1998, 1999; Park and Kim, 2000; Patel et al., 1998). On the other hand, other studies failed to find unequivocal and stable effects (Dias and Sousa, 1997; Hofman and van Oostendorp, 1999; Jonassen and Wang, 1993; Stanton and Baber, 1994; Stanton et al., 1992). Given the complexity of hypertext and hypertext use, this discrepancy may well be accounted for by differences in tasks (e.g. closed vs. open, search vs. browse), participants' characteristics (e.g. spatial/verbal ability, learning style, experience, prior knowledge), effect types (e.g. efficiency measures like processing time, evaluation measures, effectiveness measures like comprehension, recall, and accuracy), and methodological rigour (Chen and Rada, 1996; Dillon and Gabbard, 1998). And this summary does not even include the design characteristics of the map tools themselves, an equally important, albeit less investigated, source of variation.

It seems that standard usability research concentrates on the discussion of effects instead of on the analysis of the function, implementation, and design of navigation tools in relation to users' tasks. Again, navigation maps are illustrative in this respect. They provide users with cues related to different types of cognitive tasks, and hence also to different types of mental representation (Boechler, 2001). Hypertext users can be seen as engaging in three types of cognitive tasks, i.e. pragmatic, semantic, and perceptual tasks, which may be claimed to refer to three hierarchical layers of mental representation: the 'pragmatic' layer of planning, setting (sub)goals, and monitoring task execution; the 'semantic' layer of building a coherent survey of the information content;

and the ‘perceptual’ layer of representing the course of the task in terms of time, space, and supporting actions (e.g. screen management, hand/eye coordination, and mouse/keyboard management).

If we consider maps as graphical representations of content nodes and the links between them, they, by definition, combine content and structure information. The labels predict content, and their spatial organisation suggests a hierarchical organisation (as in top–down or left–right tree structures or diagrams, centre–periphery spider structures, and indented lists<sup>1</sup>) or a non-hierarchical organisation (as for example in a network-like structure). That maps contain both structure and content information makes them good candidates for multiple effects on content representation, task planning, monitoring, execution etc. Moreover, additional design characteristics of maps can make them more rich and suited to support semantic, pragmatic, and perceptual tasks. This is true for hypertext practice, which is far ahead of research when it comes to animating and visualizing digital environments (cf. fisheye interactive maps, 3D molecular models, dynamic diagrams etc.<sup>2</sup>), but also for hypertext research. The navigation maps that are used in usability experiments display a meaningful variation. Firstly, maps either represent part of the information space structure, as the localised spatial maps in McDonald and Stevenson (1998, 1999) or the fisheye view map in Gupta and Gramopadhye (1995), or they survey the global hierarchy of the information space, either in a top–down fashion (Boechler and Dawson, 2002) or in a left–right mode (Patel et al., 1998). Secondly, maps differ in the degree to which they reflect familiar knowledge structures. They may be fairly ad hoc (McDonald and Stevenson, 1999) or more familiar, as for example the structural overview in Hofman and van Oostendorp (1999), which reflects a cause-and-effect analysis of the knowledge domain involved, or the maps in Jonassen and Wang (1993) and Patel et al. (1998), which are constructed on the basis of expert domain knowledge. Thirdly, maps can be upgraded by adding semantic information to the relations between information chunks. Examples are the so-called conceptual maps in McDonald and Stevenson (1999) and the graphical browser in Jonassen and Wang (1993), in which relations between chunks are visualised by captions indicating the semantic relatedness between the nodes involved.<sup>3</sup> Fourthly, maps can be upgraded pragmatically. They can provide information on the task or navigation history by marking the links visited (Mat-Hassan and Levene, 2001; Park and Kim, 2000), or they can allow users to manipulate the content structure according to the task requirements, e.g. by enabling users to define their own links, as is suggested in Stanton and Baber (1994). Finally, maps differ in the degree to which they enable ergonomic access to information. An important feature in this respect is whether map nodes are clickable and hence allow direct access.

<sup>1</sup> We consider an indented list a navigation map, because it uses space to order elements. In the literature, there is terminological confusion on this point. For example, Chien Chou and Sun (2000) refer to indented lists as navigational lists, whereas McDonald and Stevenson (1999) talk about content lists (as opposed to spatial maps).

<sup>2</sup> See e.g. [www.cybergeography.org/atlas/web\\_sites.html](http://www.cybergeography.org/atlas/web_sites.html)

<sup>3</sup> We restrict the notion of semantic enrichment to adding explicit semantic content to a map. The notion can be confusing, as can be seen in Patel et al. (1998). In their experiments, they used an alphabetical content list as well as a so-called ‘semantically enhanced’ navigation map, which—as far as can be concluded from the description—adds hierarchy and categorisation to the content list, but does not add a semantic specification of links or nodes.

What this analysis makes clear is that navigation maps have a wide spectrum of functional characteristics. They may differ in the way they support content, structure, task, and information access. In research on navigation maps these characteristics are often confounded, making it difficult to draw conclusions about their distinct contributions to the effects found.

## 2.2. *Disentangling information types in navigation tools*

There are different ways of experimentally disentangling map characteristics and functions. First, the structural characteristics of maps can be manipulated. Boechler and Dawson (2002) constructed four navigation tools with identical content but with decreasing degrees of structural cueing. The structure cues ranged from full to hardly any hierarchical information: a typical spatial/hierarchical map, showing the global structural hierarchy of chunk labels, a spatial navigation tool containing configurations of related chunk labels without explicit information on their hierarchy, a hierarchical content list containing (upper case) higher order labels and (lower case) sub-labels, and an alphabetical content list. By using multidimensional scaling, they showed systematic differences in the path data of the participants in the different conditions. In general, the available research results seem to indicate that structurally rich maps are more beneficial than alphabetical indexes in terms of efficiency and effectiveness (Bernard, 1999; Dee-Lucas, 1996; Dee-Lucas and Larkin, 1995; Gupta and Gramopadhye, 1995; McDonald and Stevenson, 1998; Patel et al., 1998). This suggests that the structural survey function of navigation maps is beneficial in hypertext tasks.

A second way of disentangling tool functions is by varying the content of navigation maps. Thus, McDonald and Stevenson (1999) compared the effect of localised spatial maps and conceptual maps, in which captions indicating the semantic relationship between the nodes were added to the link lines between nodes. Conceptual map participants performed better in a delayed comprehension (retention) task than spatial map participants. This result supports the suggestion that (additional) semantic help supports comprehension and learning more than navigation.

These results suggest the relevance of structural as opposed to content cues. Yet, navigation maps combine structure and content and hence cannot provide us with evidence on the effect of each separate function. There are, however, tools that might shed light on the distinctive effect of structure and content, i.e. empty maps and advance organisers. Empty maps consist of a structure of information slots with no content. To our knowledge, there are no usability experiments that have investigated the effect of empty structures, probably because they seem to be odd in terms of functionality.<sup>4</sup> Investigating the effect of empty structures may shed light on the role of spatial information in executing hypertext tasks (Boechler, 2001; Farris et al., 2002). But we will leave this point for a next occasion.

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<sup>4</sup> Empty boxes in a spatial structure may be functionally enriched by adding different types of information which do not relate to content, but which are relevant in terms of the information selection and navigation, such as the size of the node, the distance between nodes, the medium in which the information is packed, and the time needed to load pages. This would probably make 'contentless' structures more functional than one may think.

In this study, we concentrate on advance organizing hyperlink previews, which provide users with semantic help without giving them any structural cues.

### 2.3. *Local content tools: the case of hyperlink previews*

Hyperlink previews or advance organisers are clear examples of content tools. They provide extra information on the nature of the information that is accessible through an individual link. For example, Foltz (1996) constructed a hypertext in which non-coherent transitions were complemented with additional content information to make the relationship between the nodes more coherent and comprehensible. Foltz defined non-coherent transitions on the basis of a previous analysis of macropropositions in the text. The idea was that readers studying information in hypertext needed these semantic additions as a compensation for the less coherent nature of hypertext. As such, Foltz makes the plausible connection between content help and hypertext comprehension, analogous to the connection between structure help and hypertext navigation. Unfortunately, the semantic help did not result in better comprehension or recall of macropropositions. Similar results were obtained by Jonassen and Wang (1993). They constructed a hypertext in which each referential link was connected to a pop-up window that contained some sort of macroproposition of the target node. Again, however, this semantic tool did not result in more thorough knowledge about the hypertext information in terms of recall, or more specific measures of the user's semantic knowledge (proximity between nodes, semantic relationship between nodes, analogies between nodes). Similarly, Zhao et al. (1994) added labels to referential links that referred either to the type of the relationship (has contrast with, is an example of, etc.) or to the content or the goal of the information (to see the brief description of...). The tool resulted in slight improvements in comprehension and attitude measures. However, no differences were found in terms of navigation behaviour, such as browsing time or number of different pages visited.<sup>5</sup>

More recently, Cress and Knabel (2003) investigated the effect of link previews on navigation and knowledge acquisition in two types of tasks, i.e. browse and search tasks, representing incidental and intentional learning, respectively. They offered participants a hierarchically structured hypertext with two types of local navigation tools, i.e. a forward tool, that activated a navigation tree with lower level links, and a backward tool, consisting of a back button and a button opening the higher level node. On top of that, half of the participants received previews related to the hyperlinks. The previews were activated by a click on a link and consisted of a pop-up window, covering the central part of the screen, in which the semantic gist of the intended node was summarised. Results showed that previews improved learning. Preview participants gave more correct answers, and, remarkably, preview participants in the search condition performed better only on questions that were not related to the search task. This suggests that previews promote incidental learning. Moreover, previews improved navigation behaviour as evidenced by a decrease in the number of pages opened and a decrease in the use of the backward tool. But they did not result in better search results.

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<sup>5</sup> Zhao et al. call these typical efficiency and navigation measures 'learning processes revealing measures'.



In sum, these studies investigated a fairly clear-cut navigation tool within fairly clear-cut usage conditions. They focused on local previews containing semantic information, and they looked at their effects within a situation that seems suited to this tool, i.e. users studying information and learning from hypertext.<sup>6</sup> Yet, the results overall are far from unanimous. Cress and Knabel and Zhao et al. found learning effects, whereas Foltz and Jonassen and Wang did not. Cress and Knabel and Jonassen and Wang found differences in navigation behaviour, whereas Foltz and Zhao et al. did not.

#### *2.4. The effect of semantic and pragmatic previews*

The study of previews or advance organisers originates in Ausubel's (1968) work and is rooted in the tradition of research into education, knowledge construction, and active learning. This framework can be applied to the study of previews in hypertext as well. A study that could serve as starting point is Mautone and Mayer (2001). They investigated the influence of four different signalling devices on learning scientific explanations from multimedia presentations. Two of these devices are relevant here: introductory content summaries and relational connectives (e.g. as a result).<sup>7</sup> In the area of learning and instruction, content summaries and relational connectives are known to help the semantic processing of information (in terms of recall and transfer). Less is known about their use and function in hypertext. A global summary preview, common in paper documents, is rather unusual in hypertext, where structure maps, as we have seen them above, are the new global survey standard.<sup>8</sup> Relational tools, displaying the semantic relationship between links and nodes, are unusual in hypertext as well. They have been used in experimental settings with little effect (Jonassen and Wang, 1993; Zhao et al., 1994), but they are highly unusual in hypertext practice. The unpopularity of verbal summaries and relational cues in hypertext is consistent with the unpredictable, non-linear use of hypertext information. Verbal summaries often describe a conceptual and semantically coherent ordering of information, whereas maps only represent structure and allow instant access to all information units. Likewise, local relational tools support the understanding of the relationship between two successive nodes, thereby suggesting a particular processing sequence, which is not necessarily in accord with the actual sequence of the user. Instead, hypertext users more likely benefit from prospective previews that enable them to select the next step.

This makes it understandable that hypertext practice has a preference for local previews, attached to hyperlinks and characterizing the node in question only. Mautone and Mayer account for the function of advance organisers by relating them to the three main phases in their knowledge-construction model: guiding attention, organizing knowledge, and integrating knowledge. Local previews, they claim, guide the attention of the user in a stepwise fashion. Applied to hypertext, local previews may most likely help readers by facilitating the selection of each next step. As can be seen in current hypertext

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<sup>6</sup> Unlike the other studies, Cress and Knabel used both studying/browsing and search tasks.

<sup>7</sup> The other two types of advance organisers studied are headings (which are largely comparable to hyperlinks, being the standard advance organising device in hypertext) and boldfaced content words.

<sup>8</sup> Summary previews can be multimodal (and effective) as well, as is shown in Chun and Plass (1996).



practice, this guiding function take two forms, reflecting two basic types of hyperlinks, i.e. content oriented, semantic hyperlinks (e.g. about us) and task oriented, pragmatic hyperlinks (e.g. contact). Accordingly, previews may contain two types of information, reflecting two levels in the execution of hypertext tasks: information on the content of nodes (semantic preview), and information on how this information fits in with the goals of the user (pragmatic preview). Given the inherent goal driven nature of hypertext use as well as the fragmented presentation of hypertext information, one may assume that pragmatic, task oriented previews, more than content oriented previews, are natural and beneficial to hypertext users.

In sum, the nature of hypertext use and hypertext tasks requires unpredictable, fragmentary, and non-linear use of information, making it plausible that local semantic and pragmatic previews are useful selection tools.<sup>9</sup> Furthermore, one may assume that local previews have limited if any effect on the recall or comprehension of knowledge: Once the user has planned the next step, the preview loses its impact. On the basis of these considerations, the following hypotheses can be formulated. In the first place, local previews increase the efficiency of task execution. Secondly, local previews do not (necessarily) enhance the global knowledge of the information environment. And thirdly, task oriented previews are more effective than purely semantic previews in a problem solving task.

### 3. Experiment

#### 3.1. Method

##### 3.1.1. Material and apparatus

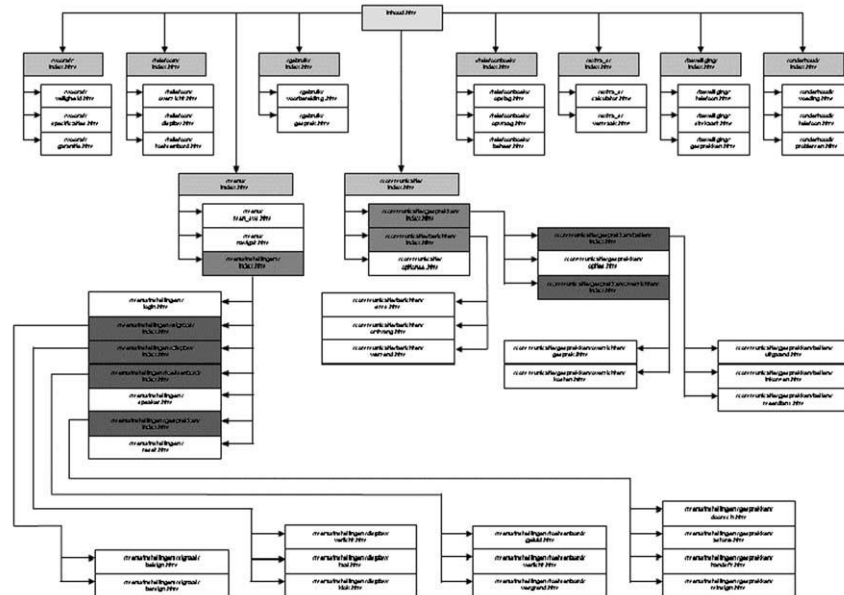
A hypertext environment for a fictitious mobile phone was constructed. Although the phone itself was fictitious, the information in the manual was not. The electronic manual contained information from different existing paper user manuals for mobile phones, thus assuring the environment to be highly realistic. We deliberately chose a hypertext environment with a limited scope in terms of content, application, and intended audience, as to create a natural basis for distinguishing between declarative, semantic information (what the information is about) and procedural, pragmatic information (how to execute a task). This made it easy to construct clearly different semantic and pragmatic hyperlink previews.

The hyperspace contained nine information categories, each with two to four information levels. The information structure is given in Fig. 1. Altogether the website contained 65 web pages, 19 of which were menu pages. The total environment contained 14,500 words with an average of 325 words per node.

All hyperlinks were realised by a noun (menu, display, communication, safety, etc). Although it could not be avoided that the hyperlinks contained some information,

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<sup>9</sup> This is not to say that hypertext by definition presupposes non-linear and unpredictable information sequencing. Structured hypertexts are natural in many domains, for example in e-learning and collaborative work environments, as is evidenced e.g. in You and Rada (1994).



the labels were kept as generic and uninformative as possible. For each hyperlink two previews were constructed: a content oriented (semantic) and a task oriented (pragmatic) preview. The two preview types provided different perspectives on the intended node. A semantic preview looked ahead at what the node information was about, and a pragmatic preview related the node information to task execution. To this end, the semantic previews contained an objective perspective and started with an ‘information on’ phrase, whereas the pragmatic previews contained a user oriented perspective and started with a ‘how to’ phrase. This resulted in pragmatic previews being on average 20% longer than semantic previews. For example, the level-one hyperlink communication is related to the following semantic and pragmatic preview, respectively: information on telephone calls, messages, and additional communication options and how can you make a telephone call, send and receive messages, and use additional communication options?

We opted for an implementation of previews which was less intrusive and more ergonomic than the previews studied in the experiments mentioned above. For instance, Foltz (1996), Jonassen and Wang (1993), and Cress and Knabel (2003), presented previews that covered a large part of the screen and required an additional click to (de-) activate. Instead, our previews did not cover other text but were positioned on a fixed location on the screen (see Fig. 2), and they were activated simply by holding the mouse pointer over a hyperlink. This way, low-level perceptual and ergonomic inconveniences could not decrease the usability of the previews. Finally, unlike Cress and Knabel (2003) and Jonassen and Wang (1993), our previews are not combined with other (structural) navigation tools, in order not to amalgamate global/structural and local help tools.

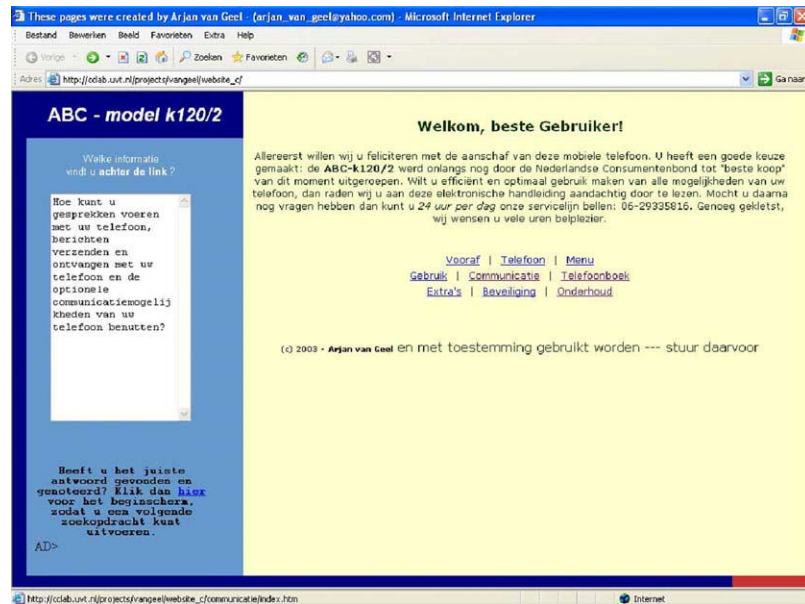


Fig. 2. Screen shot with a pragmatic preview (in Dutch) on the left.

The instrumentation consisted of the following online and offline dependent variables, measuring effectiveness, efficiency, evaluation, and recall.

**3.1.1.1. Effectiveness.** Six search questions were created, to which the participants had to find an answer in the hypertext environment. The questions differed in depth: Three of them pertained to information contained in level two of the hypertext (surface task), and three others to levels three and four of the hypertext (deep task). Surface tasks were expected to be easier than deep tasks. The difference between surface and deep tasks was introduced to control task execution. If this manipulation turned out to have effects, it would be a strong indication of the stable and reliable character of the effects.

**3.1.1.2. Efficiency.** Task execution was logged using a customly configured Apache web server. The server registered click streams and time stamps, enabling the measurement of search time, number of clicks and unique nodes, distribution of time over the nine content categories, and number of 'home runs'.<sup>10</sup>

**3.1.1.3. Evaluation questions.** Six seven-point Likert-scale statements were constructed that evaluated the website (comprehensibility, completeness, user friendliness, accessibility, usability, effectiveness). Three were formulated positively and three negatively. The reliability of the six questions was good (Cronbach's  $\alpha = .90$ ). In addition,

<sup>10</sup> By customizing the browser toolbar, the use of the back button was disabled, thus eliminating a powerful navigation tool in favour of a more structural navigation strategy.

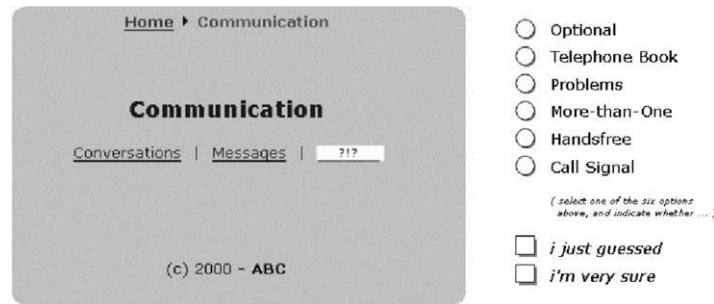


Fig. 3. Example of structure recognition task.

one seven-point Likert-scale measured the user's disorientation. For the two preview conditions, three more seven-point Likert-scale statements were constructed that evaluated the previews (use, clarifying nature, usefulness).

**3.1.1.4. Recall.** Six structure recognition questions were constructed. They had the form of a multiple-choice question, consisting of a screen dump of a menu page, with one blank space in it. On the right, six hyperlink labels were presented, one of which fitted into the blank space (for an example, see Fig. 3). Participants had to choose the right option, and indicate their feeling of knowing (Are you sure? Is this a guess?).

### 3.1.2. Design, participants and procedure

The experiment used a post-test only, between-subjects design, with preview type as independent variable. Each participant was exposed to either a website version with no previews, a website with semantic previews, or a website with pragmatic previews.

Forty-five participants volunteered in the experiment, 28 male and 17 female. The average age was 31. The youngest participant was 19, the oldest 74. The participants had different levels of schooling. About half of the subjects had received higher education, the other half secondary education, and one participant only basic education. They also differed in type of occupation: house wife, teacher, worker, manager, pensioner, student, etc. The mixed composition makes the participant group representative for the type of task involved, i.e. using and installing a mobile phone. The participants had average computer, Internet and mobile phone experience (a mean of 4.38, 4.44, and 4.18, respectively, on a seven-point scale). Their attitude towards the Internet and mobile phones was fairly high (5.87 and 5.29, respectively, on a seven-point scale).

The experiment was run on an IBM Thinkpad notebook computer with an external USB scroll mouse and Apache and Internet Explorer installed. Each participant was randomly assigned to one of the three website versions.

The participants were instructed to imagine that they had bought a second-hand cell phone without a user manual, and that they had to use an electronic user manual on the Internet in order to answer a number of phone related questions. At this point, the participants in the preview conditions were explicitly shown the preview navigation facility available on the website. It was made clear to them that the answers to the questions were to be found on the website, and that they were not to worry about good or bad performance.

Table 1  
Efficiency results (means per task)

	Without previews	With previews
Search time (sec)	120.59	82.19
Nodes visited	16.41	10.18
Unique nodes visited	10.16	7.03
Categories visited (max 9)	3.32	2.20
Return to homepage	2.89	1.24

The time needed to search, the number of nodes visited, the number of unique nodes visited, the number of categories visited, and the number of returns to the homepage as a function of website version (without previews, with previews).

Next, participants received the first search task instruction on the screen. After having read the question, they had to press the return button. The homepage of the digital manual appeared and participants started searching for the answer to the question. When they had found the answer, they had to write it down on paper, press a special button on the screen, and return to the next search task screen. This procedure was repeated until all tasks had been completed. It was decided to have the participants write down the answers instead of typing them in, in order to keep the computer interface simple. Combining reading, searching, and writing tasks on the same screen would unnecessarily complicate the measurement.

After the tasks had been completed, the participants were handed out the evaluation questions, the structure recognition tasks, and finally the personal questions. The experiment took about 30 min.

### 3.2. Results

The results of six participants were removed from the data. Two of them made too many errors on the search tasks (more than four out of six), four others kept on searching until they coincidentally found the answer. This resulted in excessive search times and clicking behaviour (more than twice the average). Finally, in one case, the online log failed. Hence, the reported online results are based on the data of 38 participants, and the offline results on the data of 39 participants.

#### 3.2.1. The effect of previews

Table 1 shows the mean efficiency results in the conditions with and without previews. A univariate analysis of variance showed that participants with and without previews significantly differed on all efficiency variables in the expected direction: Participants in the preview condition searched faster:  $F(1, 38)=3.73$ ,  $MSE=3492.62$ ,  $p<.05$ , visited less information nodes:  $F(1, 38)=9.15$ ,  $MSE=37.58$ ,  $p<.01$ , used less unique nodes:  $F(1, 38)=9.23$ ,  $MSE=9.42$ ,  $p<.01$ , visited less information categories:  $F(1, 38)=18.69$ ,  $MSE=0.59$ ,  $p<.001$ , and less often returned to the homepage  $F(1, 38)=19.78$ ,  $MSE=1.22$ ,  $p<.001$  than participants in the condition without previews.<sup>11</sup>

<sup>11</sup> The results showed the expected effect of task complexity as well: the three surface tasks were executed faster and with less (unique) nodes than the deep tasks.

Table 2  
Effectiveness and evaluation results (means per participant)

	Without previews	With previews
Finished search tasks (max 6)	5.07	5.07
Structure recognition (max 6)		
Without guess correction	2.36	2.96
With guess correction	0.85	1.48
Usability of the website (max 7)	4.44	4.99
Perceived disorientation (max 7)	4.29	4.12

The number of successfully finished search tasks, the number of correctly recognised information structures, the evaluation of the usability of the website, and the disorientation perceived during the task as a function of website version (without previews, with previews (means per task)).

Table 2 displays the mean results for task effectiveness, website evaluation, and task evaluation in the conditions with and without previews. Participants with and without previews did not differ in their search success ( $F < 1$ ), nor did they differ in the degree in which they recognised and recalled partial structures: without guess correction:  $F(1,39) = 2.15$ ,  $MSE = 1.52$ ,  $p = .15$ , with guess correction  $F(1,39) = 1.69$ ,  $MSE = 2.10$ ,  $p = .20$ .<sup>12</sup> Likewise, participants did not differ in their evaluation of the usability of the websites:  $F(1,39) = 1.60$ ,  $MSE = 1.72$ ,  $p = .21$ . Finally, the perceived disorientation of participants in the different conditions did not differ:  $F < 1$ .

### 3.2.2. The effect of preview type

Table 3 shows the mean results for efficiency, effectiveness, and evaluation. Univariate analyses of variance showed that semantic and pragmatic previews did not produce significant differences on any of the measures used: efficiency, correct search results, and structure recognition:  $F < 1$ , accessibility:  $F(1, 25) = 1.12$ ,  $MSE = 3.07$ ,  $p = .30$ , effectiveness:  $F(1,25) = 1.02$ ,  $MSE = 3.08$ ,  $p = .32$ , usability of the website overall:  $F < 1$ . Finally, the evaluation of the previews did not differ significantly (preview use:  $F < 1$ ), nor did clarity:  $F(1, 25) = 1.47$ ,  $MSE = 1.84$ ,  $p = .24$ , or usefulness:  $F(1, 25) = 1.85$ ,  $MSE = 1.99$ ,  $p = .19$ .

## 4. Discussion

In this experiment, the differences between the three website versions were intentionally kept small, by using non-intrusive and easy to use previews. Furthermore, relatively easy search tasks were used within a relatively small and structurally simple hypertext environment. This way, it was possible to concentrate on subtle differences of previews and preview types in terms of local navigation behaviour. The results showed a clear effect of previews on the efficiency of the search process, a result that corroborated the findings of Cress and Knabel (2003). The experimental conditions underpinned

<sup>12</sup> Guess correction means that only those answers were taken into account that participants were certain of. If, however, participants were certain of an answer which appeared to be incorrect, a point was subtracted.

Table 3

Efficiency (mean search time, mean number of nodes visited, mean number of unique nodes visited, mean number of categories visited, mean number of returns to the homepage), effectiveness (mean number of successfully finished search tasks, mean number of correctly recognised structures), and evaluation (mean scores on usability of the website and on evaluation of previews and preview use) as a function of website version (semantic or pragmatic previews)

	Semantic previews	Pragmatic previews
<i>Efficiency</i>		
Search time	89.06	74.07
Nodes visited	10.66	9.61
Unique nodes visited	7.13	6.90
Categories visited	2.19	2.22
Return to homepage	1.30	1.16
<i>Effectiveness</i>		
Finished search tasks	5.14	5.00
Structure recognition		
Without guess correction	2.86	3.09
With guess correction	1.36	1.64
<i>Evaluation of website</i>		
Usability of the website	5.17	4.77
<i>Evaluation of previews</i>		
Usefulness of previews	5.50	4.73
Clarity of previews	5.57	4.91
Preview use	5.36	4.73

the significance of these efficiency differences: Even in a relatively uncomplicated search situation robust differences in efficiency show up. In particular, previews decreased processing time and different types of clicking actions (total number of clicks, unique links, information categories, homepage jumps).

Effectiveness and evaluation measures did not result in differences in favour of previews. As in [Cress and Knabel \(2003\)](#), the preview participants did not find more or more correct answers. Furthermore, they were not able to complete more structure maps correctly, and the evaluation results did not differ either. Partly, these results can be explained by the simplicity of task and content, partly also by the nature of the preview tool. The small size of the hypertext and the low complexity of the questions are good reasons to expect a high search success rate, and thus a ceiling effect in the results. Similarly, the simple experimental tasks may result in a low degree of user's frustration and hence in high evaluations irrespective of website version.

Still, it remains to be said that this same experimental environment apparently did not prevent previews to have clear efficiency effects. Therefore, it may be assumed that this local preview tool is perfectly suited to guide users efficiently through their search path, rather than helping users to recall or comprehend the content of nodes or to survey the structural organisation of nodes. As such, previews fit in with the step-by-step goal orientation of hypertext users, who have to evaluate the hyperlinks on each new page in terms of their search goal. During this process, the availability of previews apparently speeds up decision making, without any additional cost in terms of clicks, motions or time.



Table 4

Interaction between efficiency measures of the first and the last task (mean search time, mean number of nodes visited, mean number of unique nodes visited, mean number of categories visited, mean number of returns to the homepage) as a function of website version (with semantic or pragmatic previews)

		With semantic previews	With pragmatic previews
Search time (sec)	First task	67.42	96.10
	Last task	59.50	30.30
Nodes visited	First task	4.92	8.40
	Last task	11.33	4.80
Unique nodes visited	First task	4.00	6.10
	Last task	6.67	4.10
Categories visited (max 9)	First task	1.83	2.50
	Last task	2.17	1.50
Return to homepage	First task	1.00	1.50
	Last task	1.33	0.50

Within the same line of reasoning, task oriented, pragmatic previews were expected to be more efficient than semantic previews as they explicitly fit in with the goal oriented perspective of the user. The results, however, did not support this hypothesis. The results showed no difference at all between the two types of previews. A number of explanations can be put forward. First, a possible positive effect of task oriented previews may have been neutralised by the increase in length of task previews, as they were on average 20% longer than content previews. Secondly, pragmatic previews may be considered as more unusual than content previews. Manual and website users are not acquainted with the personal task oriented formulation that was used in the task oriented previews. Put in more general terms, users are used to schemes and external information that is organised and presented semantically, rather than pragmatically. Cozijn, Meas, Schackman and Ummelen (Ms.) showed that searching users benefited more from semantically organised websites than task oriented websites. However, they demonstrated a clear learning effect during task execution: Their participants gradually benefited more from task oriented structures than from semantically organised structures as task execution proceeded.

A similar effect was observed in the present experiment (Table 4). A post hoc repeated measures analysis with task number (first vs. last task) and preview type (semantic vs. pragmatic preview) as independent variables revealed a significant interaction effect between the two for nodes visited:  $F(1,20)=3.22$ ,  $MSE=84.88$ ,  $p<.05$ , one sided), categories visited:  $F(1,20)=3.99$ ,  $MSE=1.22$ ,  $p<.05$ , one sided), and returns to homepage:  $F(1,20)=4.16$ ,  $MSE=1.17$ ,  $p<.05$ , one sided). The other measures showed no effects (search time:  $F(1,20)=1.72$ ,  $MSE=5316.51$ ,  $p=.21$ ; unique nodes visited:  $F(1,20)=2.42$ ,  $MSE=24.57$ ,  $p=.14$ ).

These results suggest that users learn to use pragmatic previews more efficiently as they progress through the experiment, whereas such a learning effect is absent in the case of semantic previews. This interaction may be explained by two contrasting effects. First, pragmatic previews seem intrinsically more appropriate to the goal oriented, searching hypertext user than semantic previews. And second, the fact that users are initially less familiar with pragmatic previews than with semantic ones.

## 5. Conclusions

The results of the experiment suggest that local semantic navigation help, in the absence of any other structural tool or help, improves task efficiency considerably. It is reasonable to assume that it assists users in their selection process at each successive step in their search task. Less clear is how these local selection processes relate to higher order processes of task monitoring or conceptualising the global structure of the hypertext environment, since task execution nor structure recognition benefited from the previews. However, it cannot be excluded that a more complex hypertext environment or a higher order task, such as explaining or drawing the structure of the hypertext, might reveal effects on a more global level of task performance, such as incidental learning or conceptualisation of information.

The results offer only indirect support for the effect of a task oriented conceptualisation of information in previews. The post hoc analysis suggests that users initially do not benefit from task based descriptions, but that they learn to appreciate their informativeness over time. This learning effect during task execution suggests that pragmatic previews eventually improve task efficiency. A tentative explanation would be that, at the outset, users expect to find declarative information based on semantic schemes, and that the violation of this expectancy results in a disadvantageous starting position for task based information. The data do not allow for conclusions on how this benefit relates to higher order processes of hypertext task execution. One may assume that a more direct match between preview type and hypertext task improves task planning and task monitoring processes, but this assumption can only be tested in more complex hypertext environments or with more global types of dependent measures.

In sum, the results support a step-by-step selection function of previews. This function most likely applies to situations where users have to navigate in unfamiliar environments. Users most probably can do without previews to select and access familiar information on frequently visited websites, just like drivers can do without signposts on their routine way home from work.

As exemplified above (see Section 2), lack of strictness in the control of relevant factors produces ambiguous, if not uninterpretable, results when conducting hypertext usability research. It is easy to see that avoiding this trap might lead to falling into another, that of producing equally uninterpretable, but now ecologically challenged data. We hope to have steered clear of both pitfalls. On the one hand, the experimental procedure allows for the measurement of comparable data in a highly controlled environment, ruling out alternative explanations as much as possible. The choice of participants, materials, and tasks, on the other hand, make the results applicable to a large number of everyday digital tasks. Nowadays, thousands of hypertext user manuals can be found on the Internet, to be consulted whenever user problems arise. They all look pretty similar to the one we used in the experiment. The constructed tasks may be artificial in the experimental setting, but they represent problems everyone can have with his or her mobile phone. Furthermore, the type of information used, i.e. user manuals, typically represents the non-linear use of documents, at least for the many users who are not used to read the entire manual, but consult it whenever problems come up in using the device. Therefore, the results in the experiment may make us assume that local previews or mouse-overs connected to hyperlinks are beneficial to help users decide on the next step in many situations of ‘unpredictable’ hypertext use.

## References

- Ausubel, D.P., 1968. *Educational Psychology*. Holt, Rinehart and Winston, New York.
- Bernard, M., 1999. Sitemap design: alphabetical or categorical [Usability News]. Retrieved May 27, 2004, from the World Wide Web: <http://psychology.wichita.edu/surl/usabilitynews/1s/sitemap.htm>.
- Boechler, P.M., 2001. How spatial is hyperspace? Interacting with hypertext documents: cognitive processes and concepts. *CyberPsychology & Behavior* 4 (1), 23–46.
- Boechler, P.M., Dawson, M.R.W., 2002. Effects of navigation tools information on hypertext navigation behavior: a configural analysis of page-transition data. *Journal of Educational Multimedia and Hypermedia* 11 (2), 95–115.
- Chen, C., Rada, R., 1996. Interacting with hypertext: a meta-analysis of experimental studies. *Human-Computer Interaction* 11, 125–156.
- Chien Chou, H.L., Sun, C.-T., 2000. Navigation maps in hierarchical-structured hypertext courseware. *International Journal of Instructional Media* 27 (2), 165–182.
- Chun, D.M., Plass, J.L., 1996. Facilitating reading comprehension with multimedia. *System* 24, 503–519.
- Conklin, J., 1987. Hypertext: an introduction and survey. *IEEE Computer* 20 (9), 17–41.
- Cozijn, R., Maes, A., Schackman, D., Ummelen, N. Structuring job related information on the intranet. An experimental comparison of a task versus an organization based approach (Ms.).
- Cress, U., Knabel, O.B., 2003. Previews in hypertext: effects on navigation and knowledge acquisition. *Journal of Computer Assisted Learning* 2003 (19), 517–527.
- Danielson, D.R., 2002. Web navigation and the behavioral effects of constantly visible site maps. *Interacting With Computers* 14, 601–618.
- Dee-Lucas, D., 1996. Effects of overview structure on study strategies and text representations for instructional hypertext. In: Rouet, J.F., Levonen, J.J., Dillon, A., Spiro, R.J. (Eds.), *Hypertext and Cognition*. Lawrence Erlbaum Associates, Mahwah, NJ, pp. 73–107.
- Dee-Lucas, D., Larkin, J.H., 1995. Learning from electronic texts: effects of interactive overviews for information access. *Cognition and Instruction* 13 (3), 431–468.
- Dias, P., Sousa, P., 1997. Understanding navigation and disorientation in hypermedia learning environments. *Journal of Educational Multimedia and Hypermedia* 6 (2), 173–185.
- Dillon, A., Gabbard, R., 1998. Hypermedia as an educational technology: a review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research: Official Publication of the American Educational Research Association* 68, 322–349.
- Elm, E.C., Woods, D.D., 1985. Getting lost: a case study in interface design. Paper Presented at the Proceedings of the Human Factors Society, Santa Monica, California.
- Farris, J.S., Jones, K.S., Elgin, P.D., 2002. Users' schemata of hypermedia: what is so 'spatial' about a website? *Interacting With Computers* 14, 487–502.
- Foltz, P.W., 1996. Comprehension, coherence and strategies in hypertext and linear text. In: Rouet, J.F., Levonen, J.J., Dillon, A., Spiro, R.J. (Eds.), *Hypertext and Cognition*. Lawrence Erlbaum Associates, Mahwah, NJ, pp. 109–136.
- Gupta, M., Gramopadhye, A.K., 1995. An evaluation of different navigational tools in using hypertext. *Computers & Industrial Engineering* 29, 437–441.
- Hofman, R., van Oostendorp, H., 1999. Cognitive effects of a structural overview in hypertext. *British Journal of Educational Technology* 30 (2), 129–140.
- Jonassen, D.H., Wang, S., 1993. Acquiring structural knowledge from semantically structured hypertext. *Journal of Computer-based Instruction* 20, 1–8.
- Kim, H., 1999. An empirical study of navigation aids in customer interfaces. *Behaviour & Information Technology* 18 (3), 213–224.
- Mat-Hassan, M., Levene, M., 2001. Can navigational assistance improve search experience? A user study. *First Monday. Peer-Reviewed Journal on the Internet* 6 (9).
- Mautone, P.D., Mayer, R.E., 2001. Signaling as a cognitive guide in multimedia learning. *Journal of Educational Psychology* 93 (2), 377–389.
- McDonald, S., Stevenson, R.J., 1998. Navigation in hyperspace: an evaluation of the effects of navigational tools and subject matter expertise on browsing and information retrieval in hypertext. *Interacting with Computers* 10, 129–142.

- McDonald, S., Stevenson, R.J., 1999. Spatial versus conceptual maps as learning tools in hypertext. *Journal of Educational Multimedia and Hypermedia* 8 (1), 43–63.
- Park, J., Kim, J., 2000. Contextual navigation aids for two world wide web systems. *International Journal of Human–Computer Interaction* 12 (2), 193–217.
- Patel, S.C., Drury, C.G., Shalin, V.L., 1998. Effectiveness of expert semantic knowledge as a navigational aid within hypertext. *Behavior and Information Technology* 17 (6), 313–324.
- Potelle, H., Rouet, J.-F., 2003. Effects of content representation and readers' prior knowledge on the comprehension of hypertext. *International Journal of Human–Computer Studies* 58 (3), 327–345.
- Rada, R., Murphy, C., 1992. Searching versus browsing in hypertext. *Hypermedia* 4 (1), 1–30.
- Stanton, N.A., Baber, C., 1994. The myth of navigating in hypertext: how a 'bandwagon' lost its course. *Journal of Educational Multimedia and Hypermedia* 3, 235–249.
- Stanton, N.A., Taylor, R.G., Tweedle, L.A., 1992. Maps as navigational aids in hypertext environments. *Journal of Educational Multimedia and Hypermedia* 1 (4), 431–444.
- Van Nimwegen, C., Pouw, M., van Oostendorp, H., 1998. The influence of structure and reading—manipulation on usability of hypertexts. *Interacting with Computers* 12, 7–21.
- You, G.-N., Rada, R., 1994. A systematic approach to outline manipulation. *International Journal of Human–Computer Studies* 41, 283–308.
- Zhao, Z., O'Shea, T., Fung, P., 1994. The effects of visible link-types on learning in the hypertext environment: an empirical study. *Computers in the Schools: The Interdisciplinary Journal of Practice, Theory, and Applied Research* 10 (3–4), 353–370.